Harlequin Duck Research and Monitoring in Montana: 1997

A Report to:

ASARCO, Incorporated
Box 868
Troy, MT 59935

Submitted by

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and
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1515 East Sixth Avenue
Helena, Montana 59620-1800

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ABSTRACT

In 1997, we conducted Harlequin Duck pair surveys (including Glacier National Park) on approximately 73.5 km of 10 streams and found a minimum of 33 males and 25 females. Pair surveys during 1974-1975 and 1989-1997 in Montana have resulted in an observed sex ratio of 1.52:1 (m:f, n =786; 474 males:312 females). Brood surveys were conducted on approximately 114 km of 14 streams (including Glacier National Park) yielding a minimum of 13 females and 37 juveniles. Ten broods were produced on 7 of the 14 streams.

Reproductive success on streams surveyed both for pairs and broods in 1997 (7 streams outside of Glacier National Park) averaged 0.30 broods per female (7 paired and 3 alone produced 3 broods) or 1.40 young per adult female (14 young produced among 10 females); average brood size at or near fledging (Class III) was 4.67 for these 3 broods (3.70 for the 10 broods observed in 1997). In Glacier National Park, McDonald Creek averaged 0.13 broods per female (11 paired and 4 alone produced 2 broods) or 0.60 young per female (9 young among 15 females). The Waterton River averaged 0.33 broods per female (3 pairs produced 1 brood) or 0.67 young per female (2 young among 3 females). Combined reproduction on 9 streams (0.21 broods per female, 0.89 young per female) was below the long-term average for the state and much below average for many drainages except the Sun River.

We continued banding Harlequin Ducks in the Flathead and Clark Fork drainages. New birds captured and banded during 1997 included 5 adult females, and 28 juveniles on 6 streams, bringing the total number banded since 1991 to 356 (59 males, 70 females, 227 juveniles). Five adult males and four adult females (not including Glacier National Park) were resighted on their breeding streams of the previous year, and four two-year old females (all from one brood) were resighted on their natal stream.

LOWER CLARK FORK POPULATION SPECIFICS

Heavy snow pack, late snow melt, and high stream flows hindered our ability to do complete pair surveys early in May, and probably had a strong influence on reproduction in 1997. A minimum of 10 adult Harlequins (5 males, 5 females) was seen on 3 streams. These included Marten Creek (3 pairs plus 1 male), Rock Creek (1 pair), Vermilion River (1 female) and Swamp Creek (no birds). The number of birds observed was below normal for all streams, except for Marten Creek where the number of pairs was typical.

Brood surveys were conducted during June and July 1997. One brood each on Marten Creek and Rock Creek was encountered. However, a number of females appeared on Marten Creek in late July (maximum single-day count was 9 on 22 July), and two males were also encountered on Marten Creek in July. Banding in the area was successful; additionally, many previously marked birds were re-observed, including a female banded as a juvenile on Rock Creek in 1995 and recaptured on Marten Creek (an inter-stream movement of about 21.5 km) in August 1997. New birds banded in 1997 included 1 female and 6 young from Rock Creek and 4 young from a brood of 6 Marten Creek.

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INTRODUCTION

The Harlequin Duck (*Histrionicus histrionicus*) is a small sea duck, which travels inland to breed on fresh water streams. Harlequins breed in western North America from Alaska and the Yukon south through western Montana to California (Harlequin Duck Working Group 1993); in eastern North America, they breed from Baffin Island south to eastern Quebec and Labrador (Goudie 1993). In the Palaearctic, they breed in Iceland, Greenland and Siberia (A.O.U. 1983). Approximately 150-200 pairs of Harlequins currently breed in Montana (Reichel and Genter 1995), with most located in the following areas: 1) tributaries of the lower Clark Fork River; 2) tributaries of the North, Middle, and South Forks of the Flathead River; 3) streams coming off the east front of the Rocky Mountains; and 4) the Boulder River (Miller 1988, 1989; Kerr 1989; Carlson 1990; Fairman and Miller 1990; Diamond and Finnegan 1992, 1993; Reichel and Genter 1993, 1994, 1995, 1996).

During the breeding season, Harlequins are found along fast mountain streams (Bengtson 1966). In many areas, Harlequins use streams with dense timber or shrubs on the banks (Cassirer and Groves 1990), but they are also found in relatively open streams along the east slopes of the Rocky Mountains, Montana (Markum and Genter 1990, Diamond and Finnegan 1992), and in the Arctic tundra (Bengtson 1972). In Idaho, 90% of observations occurred near old growth or mature timber stands (Cassirer and Groves 1990). Mid-stream rocks, logs, islands, or stream-side gravel bars serve as safe loafing sites and appear to be important habitat components.

Most of the ducks arrive on their inland breeding areas in mid-April to early-May; unmated males typically arrive before pairs (Kuchel 1977). The males return to the coast shortly after the females begin incubation; most are gone by early July (Kuchel 1977). The females and young remain on the streams until August or early September. This chronology is influenced by elevation and by the timing of spring runoff; it may vary up to several weeks between years.

The U.S. Forest Service, Region 1, lists the Harlequin Duck as "Sensitive" (Reel *et al.* 1989). The species is listed as a Species of Special Concern by the Montana and Idaho Natural Heritage Programs (Idaho Conservation Data Center 1994, Montana Natural Heritage Program 1997). The eastern North American population is listed as Endangered in Canada (Goudie 1993) and has recently been petitioned for federal listing in the United States.

The Montana Natural Heritage Program began surveying Harlequin Ducks in 1988. The survey data gave rise to questions involving site fidelity, productivity and mortality. We began marking Harlequins to a limited extent in 1991; through 1996, a total of 323. Harlequins were marked on 9 streams, representing the largest population of marked Harlequins from breeding streams. Birds marked in Montana have subsequently been captured and observed on the coasts of Oregon, Washington and British Columbia, with most reports coming from Vancouver Island (Reichel and Genter 1996, Reichel et al. 1997). Long term goals include: 1) develop a baseline status report of current and historic Harlequin populations in Montana; 2) gather information on site fidelity, reproduction, mortality, and movements to allow estimations of what constitutes a viable Harlequin population; 3) develop survey protocols for actual and potential Harlequin streams; 4) develop management guidelines for maintaining and restoring Harlequin populations and habitat; 5) identify coastal areas where Harlequins from the Northern Rockies occur; and 6) develop a model of stream characteristics needed to support Harlequin populations. Goals for 1997 included: 1) surveying additional streams (particularly those near streams with many marked

individuals) for presence and status of Harlequins; 2) gathering productivity data on some primary Harlequin streams; 3) marking as many individuals as possible on selected streams for long-term monitoring; and 4) surveying isolated streams with small numbers of ducks to begin to collect data on the long term viability of those small, local populations.

This report summarizes results from the 1997 field season and should not be considered a comprehensive analysis of all data collected from previous years (although some of the older data are presented). For a recent and relatively comprehensive summary of Harlequin Duck research in Montana through 1996 see Reichel et al. (1997).

METHODS AND MATERIALS

Harlequin Ducks were surveyed on parts of the Kootenai, Flathead and Lolo National Forests and in Glacier National Park during May-August 1997. Additional surveys were conducted by agency personnel of Glacier National Park. Most surveys were conducted by walking the stream channel (when possible) or stream bank. In most cases, the surveyor walked upstream, giving more time to observe the bird before it moved out of sight; in cases where birds were not to be marked, the surveyor made a loop around the birds to minimize disturbance. For streams in the Flathead and Clark Fork drainages, we attempted to capture and mark all birds seen when a licensed, qualified bird-bander was present on the survey (Reichel, Ashley, or Hendricks). Captured birds were sexed, aged, weighed, measured (wing cord and tail), marked, and released. Juveniles were aged based on feather development: Class I – downy, no feathers visible; Class II – partly feathered; Class III – fully feathered but flightless. Most captured birds also had blood collected for genetic analysis by Maggie Brown (Department of Wildlife, Fish and Conservation Biology, University of California - Davis). Birds were banded with a USFWS aluminum band and with a blue, plastic leg band with 2 white alpha-alpha or alpha-numeric characters. These birds are individually recognizable by the imprinted characters, although the bands are less readily observed than nasal discs, which had been used in previous years but were discontinued because of concerns about trauma and pairing success. Dates, locations, distance surveyed, and general characteristics of the stream reaches surveyed were recorded; location, number, age, and sex of all Harlequins seen was recorded, as was habitat characteristics of the site. All surveys and duck observations were entered into a database and associated ARC-INFO coverages.

In the literature and in unpublished reports, Harlequins within a geographical area are often noted as Abreeding on XX number of streams.≅ This has been variously interpreted to mean: 1) every named stream; 2) larger named streams; or 3) the major stream in an occupied drainage. Not all streams used by Harlequin Ducks during the breeding season are used for nesting or brood-rearing. Some streams where adult Harlequins are observed may be used only during migration to and from breeding areas. In order to classify Harlequin Duck observations in a consistent manner we have adopted the following definitions proposed by Cassirer et al. (1996) (the first two of which would be considered AElement Occurrences≅ [EOs] by Natural Heritage Programs/Conservation Data Centers throughout North America).

Harlequin Duck breeding occurrence:

is defined by a drainage, drainages, or portion of a drainage where breeding is known (i.e., a brood or nest has been observed within the last 15 years).

EOs are separated by either:

- ≅ A substantial barrier (>2 km over a major divide); or,
- . A 10-km separation for completely unsuitable habitat (across land);
- ≅ A 20-km separation (measured along watercourses) for both rarely used habitat (lakes, <1% gradient rivers) and for apparently suitable habitat that is not known to be occupied.

Probable harlequin duck breeding occurrence:

Same definition as above, except breeding is not known, but rather is highly suspected (i.e., there have been at least 3 independent pair or female observations within the last 15 years).

Breeding status unknown:

Drainages or portions of drainages with at least 1 harlequin duck observation but fewer than 3 independent pair or female observations during the breeding season within the last 15 years.

Breeding unlikely:

Observations of males during migration periods. The male migration periods are before 15 April and after 5 June in the Northern Columbia Basin and Rocky Mountain Front areas and before 1 May and after 20 June in the Intermountain region.

Observations of pairs outside the pre-nesting season. The pre-nesting season is from 15 April - 5 June in the Northern Columbia Basin and Rocky Mountain Front areas and from 1 May - 20 June in the Intermountain area.

Incidental observations in unsuitable habitat such as ponds or large, low gradient (<1%) rivers not adjacent to known breeding sites, or observations on streams which have been identified as lacking breeding activity (e.g. migratory staging areas or stopovers).

SURVEYS AND BANDING

MONTANA SURVEYS - 1997

In 1997 we surveyed for Harlequin Ducks along 114 km of streams (Figure 1); in some cases those included multiple surveys of the same stream reach on different dates. Harlequin Duck pair surveys were conducted on 73.5 km of 10 streams (including Glacier National Park), yielding a minimum of 33 males and 25 females. Brood surveys were conducted on 114 km of 14 streams yielding a minimum of 13 females and 37 juveniles.

Figure 1. Streams surveyed for Harlequin Ducks in Montana during 1997 by the Natural Heritage Program.

(INSERT MAP HERE) unavailable

Lower Clark Fork. Pair surveys were conducted from 6 May to 15 June 1997 along 45.3 km of 6 streams (Marten Creek, Rock Creek, Swamp Creek and the Vermilion River were surveyed at least twice in May) where Harlequin Ducks have been reported previously. A minimum of 10 Harlequin Ducks (5 males, 5 females) was seen on streams. These included Marten Creek (3 pairs plus 1 male; 3 surveys), Rock Creek (1 pair; 2 surveys), Swamp Creek (0 ducks; 2 surveys), Vermilion River (1 female; 2 surveys), East Fork of Elk Creek (0 ducks; 1 survey), and Trout Creek (1 female; 1 survey). Total numbers of ducks were below average on each of the major (first four) streams, although the number of pairs on Marten Creek was typical. Heavy snow pack, late snow melt, and high stream flows hindered our ability to do complete pair surveys in May, and probably had a strong influence on the ability of adults to locate suitable nest sites when nesting normally occurs.

Brood surveys were conducted along 45.3 km of 6 streams during 15 July to 10August 1997. A minimum of 23different Harlequin Ducks (11 females and 12 juveniles) were observed on 2 streams. Marten Creek had 5 females present with 1 brood of 6 chicks on 15 July, and 10 females and the single brood were present by 22 July. By the time of banding (8 August) only the brood of 6 and 2 lone females were present. Rock Creek had 1 female with a brood of 6 chicks on 28 July and 8 August. Swamp Creek and the Vermilion River failed to produce chicks (at least 2 surveys each) in 1997, as did East Fork of Elk Creek and Trout Creek (1 survey each).

Glacier National Park. Pair surveys were conducted along 29 km of 6 streams during May and early June 1997 by Glacier National Park personnel (J. Ashley pers. comm.). A maximum of 11 pairs, 4 males and 4 females was seen on 22 May on Upper McDonald Creek. One male was seen on Snyder Creek on 4 June, 1 pair and 1 male was present on Fish Creek on 29 May, and 3 pairs were present on the Waterton River on 3 June. No Harlequins were seen on either Sprague Creek or Olson Creek. Maximum count for all surveyed streams was 21 males and 19 females.

Brood surveys were conducted along 28.7 km of 2 streams during August 1997. Five females and 2 broods (4 and 5 chicks, respectively) were noted on Upper McDonald Creek on 12-13 August, and 1 female and a brood of 2 chicks was present on the Waterton River on 22 August (J. Ashley pers. comm.). Total ducks during brood surveys was 6 females and 11 chicks.

Other Northwest Montana Areas. Pair surveys were conducted along 5 km of 1 stream (Trail Creek) 29-30 May 1997. A minimum of 16 Harlequin Ducks (12 males, 4 females) was seen, including 3 pairs, 9 males and 1 female. These numbers are similar to 1996 (4 pairs plus 6 males and 2 females).

Brood surveys were conducted along 32.5 km of 5 streams during late July and August 1997. A minimum of 19 different Harlequin Ducks (5 females, 14 young) was observed on 4 streams. These included Grave Creek (1 female), Spotted Bear River (3 females, 6 juveniles in broods of 4 and 2), Sullivan Creek (1 female, 6 juveniles in broods of 3 and 3) and Trail Creek (2 juveniles in 1 brood). No Harlequin Ducks were observed on Cache Creek (Lolo National Forest).

SUMMARY OF MONTANA SURVEYS 1987-96

In Montana, over 3488 km of streams have been surveyed since 1987 (Reichel and Genter

1996, Reichel et al. 1997); many of these stream reaches have been surveyed in multiple years and during both pair and brood season. Not all of these streams can be considered adequately surveyed. To be reasonably sure birds are not present on a stream where no previous sightings have occurred, at least two surveys should be conducted during 1-25 May; if done in a single year, surveys should be done at least 1 week apart. Due to lack of knowledge of proper survey timing, many surveys done prior to 1992 were done during June (after males have left and females are incubating) or after 10 August when many birds in years of normal snow pack and runoff have left all but the streams in southwest Montana.

BANDING IN MONTANA: 1991-97

During 1997 in Montana, 5 adult females, and 28 juveniles were captured and banded (Table 1). This brings the total number banded since 1991 in Montana to 356 (59 males, 70 females, 227 juveniles).

Table 1. Summary of Harlequin Ducks marked for the first time in 1997 (total ducks captured in all years including 1997 are in parentheses).

Location	Male	Female	Juv.	Total
McDonald Creek, Glacier NP	(27)	2 (31)	8 (62)	10 (120)
Waterton River, Glacier NP		(1)	2 (7)	2 (8)
Trail Creek	(10)	(9)	2 (17)	2 (36)
Grave Creek		(3)	(6)	(9)
Spotted Bear River		2 (4)	6 (34)	8 (40)
Sullivan Creek, Flathead Co.		(2)	(10)	(12)
Cache Creek	(1)			(1)
Blackfoot River, North Fork		(1)	(2)	(3)
Marten Creek, Sanders Co.	(15)	(6)	4 (38)	4 (59)
Rock Creek, Sanders Co.	(4)	1 (5)	6 (17)	7 (26)
Swamp Creek, Sanders Co.	(1)	(2)	(12)	(15)
Vermilion River, Sanders Co.	(1)	(4)	(22)	(27)
TOTAL	0 (59)	5 (70)	28 (227)	33 (356)

MOVEMENT

ON THE BREEDING GROUNDS

In Montana and Idaho, several relatively long-distance movements have been documented both within and between years (Table 2). One inter-stream movement was documented in 1997, in the Lower Clark Fork drainage. A female banded as a juvenile on Rock Creek on 26 July 1995

was recaptured on 9 August 1997 on Marten Creek, a movement of about 21.5 km. We now have recorded movements between Marten Creek and the three other streams regularly surveyed in the Lower Clark Fork drainage (Rock Creek, Swamp Creek, Vermilion River), as well as with West Gold Creek in northern Idaho. Movements between Rock Creek, Swamp Creek and the Vermilion River have not been documented. This suggests that Marten Creek is an extremely significant area for Harlequin Ducks of the Lower Clark Fork sub-population.

Table 2. Significant movements of Harlequin Ducks within and between years on the breeding grounds in Montana and Idaho (Cassirer and Groves 1994, Reichel and Genter 1994, 1995; Reichel et al. 1997; Ashley 1995, 1996; Cassirer pers. comm.).

Age and sex when banded	1st Date	Location	2nd Date	Location	Km moved
Adult Male	1990	Gold Creek, ID	1991	Granite Creek, ID	14
Adult Male 755-76075	5/26/93	Marten Creek, Devils Gap	4/27/95	Vermilion River, 0.1 mi above Miners Gulch	31
Juv. Female 805-90262 changed to 925-09364	8/10/92	West Gold Creek at Lake Pend Oreille, ID	7/29/96	Marten Creek, near mouth	50
Adult Female 755-76007	8/4/92	Marten Creek, mouth of (w/ brood)	7/30/93	Swamp Creek, T25N R31W Section 9 (w/ brood)	16
Adult Female 755-76025	8/10/92	McDonald Creek above McDonald Lake (w/ brood)	6/29/95	Middle Fork Flathead River (w/ brood)	18
Adult Female 755-76013	7/28/95	Marten Creek, near mouth of (with 6 young 925-09336, 37, 38, 39, 40, 41	7/29/95	Vermilion River, near Sims Creek confluence (with same 6 young) T	26
Adult Female 925-09374	7/31/96	Grave Creek, 0.7 mi above Cat Creek	8/20/96	McDonald Creek near McDonald Falls	75
Juv. Female 775-37376	7/26/95	Rock Creek, T26N R32W S22SE	8/9/97	Marten Creek, near Devils Gap	21

The two longest movements to date were recorded in 1996. A female marked as a juvenile on West Gold Creek in Idaho in 1992 was found injured and without a brood on Marten Creek in 29 July 1996 (a 50 km movement). There have been no documented cases of females

breeding on streams farther than 20 km from their natal stream (always within the same drainage). The second long distance movement was a female marked on Grave Creek on 31 July 1996 without a brood and observed again, 75 km away, on McDonald Creek on 20, 22, and 28 August 1996 (Ashley 1997). This was likely a post-breeding exploratory movement or wandering during migration. Since no surveys had been done on Grave Creek since May, it is unknown if she had spent the summer there.

Both sexes of Harlequin Duck have been observed using different nearby drainages during different years in Montana and adjacent Idaho (Table 2); two cases of within-year drainage change by adult females have also been noted. These observations indicate that movements of up to 30 km within an aggregate of streams may occur routinely but infrequently, both within and between years. Movements occurred over large reservoirs (Noxon Reservoir) and lakes (Lake McDonald). The 1995 movement by a female and her entire fledged brood to the Vermilion River was likely the result of disturbance due to marking; however, the movement took place at least 4 hours following the release of the birds. A breeding female in Glacier Park has been seen at several locations on different streams in the park over the 4 years since her banding (Ashley 1995); locations in Table 2 are the maximum distance moved during the 4 year period.

There is little published literature regarding movement within the breeding grounds. Kuchel (1977) found that pairs used lower McDonald Creek prior to establishing home ranges higher up along the stream. Once established, pairs rarely moved more than 1-2 km, although movements of up to 8 km were recorded. Kuchel (1977) found unpaired males moved considerably more during the breeding season, with movements of up to 10 km recorded. In a reanalysis of Kuchel=s (1977) data, Cassirer and Groves (1992) found that linear home ranges during the breeding season averaged 7.7 km (SD = 2.34) on McDonald Creek, similar to the 7 km reaches used in Idaho.

On the Bow River in Banff National Park, 5 pairs of birds were marked at what is probably a staging area or local migratory corridor (Smith 1996). Two pairs remained in a 2 km section of river where they were banded, and another remained in a 2 km stretch about 12 km downstream; one pair remained within about 6 km until the female moved about 8 km up a drainage, perhaps to breed; the final pair moved about 15 km downstream within 22 days (Smith 1996).

For 35 Harlequins marked in Iceland, Bengtson (1972) found no movement between breeding streams and movement of only a few km within drainages. Not only did the birds return to the same drainage, but in 22 out of 33 cases, the birds were observed within 100 m of their locations during the previous year (Bengtson 1972).

MIGRATION

Nature of migration. All inland populations of Harlequin Duck migrate to coastal waters. A marked female seen on Granite Creek, Idaho on 17 July 1991 was relocated 13 days later near Battleship Island in the San Juan Islands, Washington (Cassirer and Groves 1992). In Iceland, birds are thought to swim up the rivers from the coastal wintering grounds to the freshwater breeding sites (Gudmundsson 1961 *in* Bengtson 1966).

Sibling juveniles may migrate together to the coast, as indicated by the presence of 3 siblings at Hornby Island, B.C. (Harlequin Duck Working Group Database, G. Schirato, Wash. Dept. Fish & Wildlife pers. comm.) which were marked together 7 months earlier on Swamp Creek, Montana. Whether females and their broods migrate together in some instances is

unknown. However, it is known that females occasionally leave prior to their young fledging. In Montana, out of 123 broods observations during 1988-97, 16 broods (13%) were found without the hen prior to migration (Reichel et al. 1997, this report, Ashley pers. comm.). Age class of the 16 abandoned broods when they were first observed alone was as follows: 2 were Class I, 3 were Class II, 3 were Class III, and 8 broods were first observed without the adult female following fledging. In one additional case, a brood of 7 was marked with the female on 11 Aug 1992; on 2 September the female was seen with 5 of her fledged juveniles, while one of the brood was observed alone 2.5 km away.

Timing and routes of migration. Of 249 Harlequins banded in Montana from 1991-1995, a minimum of 24 have been reported from Oregon (2), Washington (1), and southern British Columbia (21), including Vancouver Island and Hornby Island through September 1996 (G. Shirato pers. comm.). Sexes and ages at banding show the following numbers and percentages observed: adult females (6, 11%), adult males (2, 5%), juvenile females (9, 7%), and juvenile males (7, 5%).

We have not included resighting records for birds marked in Montana during 1996 and 1997 in the above summary, nor any birds seen following migration to the coast in 1997, as these data have not yet been thoroughly analyzed. Nevertheless, during 1997 to March 1998 more than 25 individuals banded in Montana have been reported from British Columbia (Vancouver and Hornby islands) and at least 2 birds from Washington (Harlequin Working Group pers. comm., numerous observers). Resightings include 7 adult males, 4 adult females and 2 juveniles from the Lower Clark Fork streams: Rock Creek (2 males, 1 female, 2 juveniles), Swamp Creek (3 males, 1 female), Marten Creek (1 male, 1 female), Vermilion River (1 male, 1 female). Additional coastal resightings during 1997-1998 for birds banded on other Montana streams included McDonald Creek (7 males, 3 females), Trail Creek (1 male), Spotted Bear River (1 female) and North Fork of the Blackfoot River (1 male, 1 female).

Migratory behavior. It is believed that nearly all one-year-old birds, and some (perhaps most) two-year-old birds remain in coastal water, not moving to breeding streams until they are 2-4 years of age. The proportion of each age class that stays on the coast has yet to be determined, but indications are that one-half of 2-year-old females and one-quarter of 3-year-old females do not return to the breeding grounds. We encountered five 2-year-old females during our 1997 surveys of the Lower Clark Fork streams. Four of these females were on their natal stream (Marten Creek) and 3 were siblings. The fifth female was born on Rock Creek and was encountered on Marten Creek (see Table 2). Wallen (1987) reported that a 1-year-old female (of 11 total) returned to her natal stream (Upper Moose Creek) in Grand Teton National Park in 1986. This is the only report of a 1-year-old female on the breeding grounds. No one- or two-year-old males, out of 246 observations of males, have been seen in Montana during 1992-96 surveys (Table 7, Ashley pers. comm.).

DEMOGRAPHY AND POPULATIONS

MEASURES OF BREEDING ACTIVITY

Age at first breeding; intervals between breeding. Only a single known-aged male has been seen with a mate; it was marked by MTNHP as a juvenile in 1992 on Mineral Creek, Montana, and observed by J. Ashley paired with a female (white NH) at Hornby Island, BC, in

March 1996. Adult male breeding plumage is attained at three years of age (Phillips 1925). No one- or two-year-old males, out of 246 independent male observations, have been observed in Montana during 1992-96 surveys (Table 7, Ashley pers. comm.). Very few, if any, 1 or 2-year-old males have been reported on the breeding grounds in North America. Yearling males make up 1-2% of the population on the breeding grounds in Iceland (Bengtson 1972, Gardarsson 1979).

The youngest female known to have bred is a 2-year-old which raised a brood of 3 in 1994 on Trail Creek, Montana; 14 additional non-breeding (or not successfully breeding) 2-year-olds have been observed on natal streams and at least 25 marked 2-year-olds are known to have been alive. Only a single 3-year-old has bred successfully (on Marten Creek in 1995); 8 additional non-breeding 3-year-olds have been observed on natal streams, and 17 marked 3-year-olds are known to have been alive. Only a single 4-year-old has bred successfully (on Marten Creek in 1996); 9 additional non-breeding 4-year-olds have been observed on natal streams, and 11 marked 4-year-olds are known to have been alive. One 5-year-old female is known to have bred successfully on her natal stream (McDonald Creek in 1997). Ages of females when first seen on the breeding grounds have included 2-year-olds (15), 3-year-olds (4), and 4-year-olds (2); females seen on the wintering grounds, that have not yet been seen on the breeding grounds, included 1-year-olds (2), 3-year-olds (3) and 4-year-olds (1).

Some females on breeding streams apparently do not lay eggs (Bengtson and Ulfstrand 1971, Dzinbal 1982, Wallen 1987, Cassirer and Groves 1991). Bengtson and Ulfstrand (1971) examined ovaries of 6 non-breeding females and reported that none had laid eggs. They reported that 15-30% (n=48) of adult females (based on bursae inspection) were non-breeders. Many of these non-breeding Aadults≅ may have been young (2-3 year-old) birds, since cloacal examination gives adult status to 2-year-olds.

Annual and lifetime reproductive success. Reproductive success in Montana was below average in 1997, with one of the lowest numbers of broods and young per female recorded on many streams (except the Sun River) (Table 3, 4). Values for streams surveyed in 1997 (0.21 broods per female, 0.89 young per female, 4.17 young per brood) were similar to values for 1995 (Table 4: 0.23 broods per female, 0.87 young per female, 3.82 young per brood). The data for 1997 and other years (Table 4) are not directly comparable, however, because not all streams included in surveys were identical.

Until data are available on age-specific reproduction and longevity, no lifetime reproductive success can be calculated.

Proportion of total females that rear at least one brood to nest-leaving. Harlequin Ducks raise only a single brood each year. The proportion of females successfully raising a brood in a single year varies widely between years (Table 4). In Montana during 1997, 21% of 28 females successfully raised a brood; stream surveys between 1974 and 1996 found that 349 females raised 132 broods for an average of 37.8% (range 7-55%). Throughout their range, the percentage of females which successfully raise a brood varies from 7-56% (Bengtson and Ulfstrand 1971, Kuchel 1977, Wallen 1987, Cassirer and Groves 1991, Reichel et al. 1997).

Sex ratio. During the spring pair season for all years combined, a sex ratio of 1.52:1 has been observed in Montana (m:f, n =786; 474 males:312 females). These values are based on independent male observations during the period 27 April - 31 May and the maximum number of females seen when more than one survey was done during a single season on a single stream (see Reichel et al. 1997 for more details). Cassirer (1995) found a spring adult sex ratio of 1.31:1 (m:f, n = 81) in 1995 on Idaho streams. In Banff National Park, Alberta, sex ratios varied

Table 3. Harlequin Duck reproduction in 1997 for Montana streams with both pair and brood (at fledging) surveys.

Stream	#Adult Females	#Broods	#Young
Flathead Drainage			
McDonald Creek[@]	15	2	9
Trail Creek	4	1	2
Drainage Total	19	3	11
0.16 Broods per adult female			
0.58 Young per adult female			
3.67 Young per brood			
Lower Clark Fork Drainage			
Marten Creek	3	1	6
Rock Creek	1	1	6
Swamp Creek	0	0	0
Vermilion River	1	0	0
E. Fork Elk Creek	0	0	0
Trout Creek	1	0	0
Drainage Total	6	2	12
0.33 Broods per adult female			
2.00 Young per adult female			
6.00 Young per brood			
Other Streams			
Waterton River[@]	3	1	2
Drainage Total	3	1	2
0.33 Broods per adult female			
0.67 Young per adult female			
2.00 Young per brood			
GRAND TOTAL	28	6	25
0.21 Broods per adult female			
0.89 Young per adult female			
4.17 Young per brood			

[@] from Ashley (pers. comm.)

Table 4. Harlequin Duck reproductive parameters 1974-75 (Kuchel 1977) and 1989-1996 for streams with both pair and brood surveys.

Year	# adult females	# broods	# young	broods per ad. female	young per ad. female	young per brood
1974	11	3	12	0.27	1.09	4.00
1975	15	1	2	0.07	0.13	2.00
1989	13	7	41	0.54	3.15	5.86
1990*	31	17	65	0.55	2.10	3.82
1991*	37	9	31	0.24	0.84	3.44
1992*#	71	39	132	0.55	1.37	3.38
1993#	49	21	59	0.43	1.20	2.81
1994#	30	10	40	0.33	1.33	4.00
1995#	48	11	42	0.23	0.87	3.82
1996 *#	44	14	56	0.32	1.27	4.00
Total	349	132	480			
Mean				0.378	1.38	3.64

* includes data from the Rocky Mountain Front (Diamond and Finnegan 1992, 1993; D. Whittekeind, pers. comm.)

includes data from Ashley (1994a, 1994b, 1995, 1996)

from 1.37:1 in May to 1.81 in June (Smith 1996). In Iceland, sex ratios on the breeding grounds varied from 1.17 - 2.33:1 during 5 summers in late May - early June (Bengtson 1966, Bengtson 1972, Gardarsson 1979).

In coastal British Columbia, the apparent sex ratio is 1.5:1 (544 birds) in winter, declining from to 1.4:1 (297 birds) in March-April (Campbell *et al.* 1990); this grows to 4.3:1 in May, and by July, when adult females are still on the breeding streams, it reaches 18.2:1 (n = 1633 birds).

FIDELITY TO BREEDING STREAMS

Adult fidelity to breeding stream. In Montana, 356 Harlequins (59 adult males, 70 adult females, 227 juveniles) have been banded from 1991 through 1997. In 1997, 5 males and 5 females were resighted on the streams on which they had be banded as adults in previous years (numbers from Glacier National Park not yet available). Streams included Marten Creek (4 males and 1 female), Trail Creek (1 male and 3 females) and Sullivan Creek (1 female). Through 1996, 60% of males (25 of 42) and 64% of females (36 of 56) returned at least 1 year following marking. Of females marked as adults through 1994 (n=41), 6 had a gap of one breeding season between resightings on the breeding grounds (one bird had 2 gaps of 1 year); none marked through 1993 (n=36) had a two season gap. However, a single adult female marked in 1992 had never returned to the breeding grounds but was resighted on the wintering grounds in both 1995 and 1996. In 7 of 30 cases through 1994, males marked as adults had a gap of one breeding season between resightings, and in 1of 23 cases through 1993, a two season gap. Lower return rate of males may be a result of mating with new females on the coast and following them to

female natal streams.

Fidelity to natal stream. Of 119 ducklings marked in 1992-94 in Montana, 18 females are known to have survived at least 2 years. Of the 18 surviving females, 11 were reported only from their natal stream, 2 only from the coast, and 5 from both the coast and the natal breeding stream. Seven males marked as juveniles (1992-94) were seen only on the coast; none have been reported from their natal stream (Ashley 1995, this report). In Glacier National Park, 2 of 5 ducks banded as juveniles in 1974 returned to the natal stream in 1976; both were females (Kuchel 1977). As mentioned previously, four 2-year-old females were resighted on their natal stream (Marten Creek) in 1997, and one 5-year-old female successfully raised a brood on her natal stream (McDonald Creek).

No ducklings marked from 1988-1991 in Idaho (n=27) have been re-observed (Cassirer pers. comm.). However, a duckling marked in Idaho in 1992 was found on Marten Creek, Montana, in 1996. It is not known if she attempted to breed there.

CONSERVATION AND MANAGEMENT

IMPLICATIONS OF THE CURRENT RESEARCH

Although much remains to be learned about movements, site fidelity, age-specific reproduction, and survival of Harlequin Ducks, what is known about their life history parameters highlights the precarious nature of the populations in the Rocky Mountains of the U.S. Factors that limit recolonization and increase the possibility of extirpation include: 1) high female natal site fidelity; 2) high adult site fidelity; 3) pair bonds developing on the wintering grounds; 4) low levels of movement on the breeding grounds; 5) relatively advanced age at first reproduction; 6) little chance of renesting after about 2 weeks following the start of incubation; 7) low and irregular levels of reproductive success; 8) patches of suitable habitat which are highly fragmented; 9) sensitivity to disturbance; 10) the clumped distribution of pairs, even in apparently homogeneous habitat; 10) declining range-wide and regional population levels; 11) relatively small and isolated regional populations; and 12) use of coastal wintering habitat immediately offshore (often less than 100 m).

Harlequins apparently form the pair bond on the coast and the female leads her mate to the breeding stream. Site fidelity is high, both for first-time and experienced breeders, and probably exceeds 90% for both categories. This leaves very few birds to explore and Apioneer≅ new sites. It may also be that Harlequin Ducks, like many other birds with clumped distributional patterns, key in on areas with others of the same species present. In other words, good habitat to a Apioneer≅ is where ducks are already present; empty habitat would be unlikely to be colonized. Suitable habitat in the Rocky Mountains is currently sparse and widely separated. Much has likely been lost and fragmented by development and building of reservoirs.

Small breeding populations face several challenges. Random events, such as several birds dying or several poor reproductive years caused by flooding, can dramatically reduce already small populations or eliminate them. Females do not breed until 2 or more years-old and adult success rates may not occur until 4 or more years-old. This means that mortality must be low or few ducks will even make it to breeding age. Once a duck attains breeding age, it can only produce a single brood each year. While many bird species renest when the

nests or young are lost, there is little possibility of Harlequins renesting after more than a week or two following egg laying. Males return to the coast a week or two after the females begin incubation. The result of the above factors is that reproductive success is low and highly variable. An average female is probably at least 5 years old before she has raised even 2 female ducklings to fledging. It is likely that mortality in the first 6 months following fledging is high.

Harlequins from the U.S. Rocky Mountains move to the Pacific coast off Oregon, Washington, and British Columbia following breeding and remain there until the following spring. They are concentrated in areas with rocky shorelines. Harlequins are the most coastal of wintering seaducks and are thus more susceptible to hunting and oil spills than most seaducks.

This set of facts does not bode well for the Harlequin Duck in Montana, where 10 of 27 occurrences consist of only 1 or 2 pairs of ducks. It also shows the critical nature of the 6 occurrences with more than 15 pairs as a source of stability to the Rocky Mountains regional population.

PRIORITIES FOR FUTURE RESEARCH

The following are among the top future research priorities and are primarily a subset of those listed by the Harlequin Duck Working Group (1993) and by Cassirer *et al.* (1996). The Montana Natural Heritage Program has developed research proposals to address the priorities for those questions associated with the breeding grounds and migration and is pursuing funding for them; these are available from the Natural Heritage Program.

1) What are the impacts of human disturbance on breeding and wintering Harlequin Ducks?

Several independent studies have documented the sensitivity of Harlequin Ducks to human disturbance, primarily through the relationship of sighting locations to the accessibility of those locations (Kuchel 1977, Wallen 1987, Diamond and Finnegan 1993, Cassirer and Groves 1991, 1994, Clarkson 1992, Ashley 1994). Specifically, boating has been shown to have a significant negative correlation with numbers of ducks present in one area on a medium-sized stream (Clarkson 1992, Hunt 1993). Observations in other areas tend to support this conclusion (Cassirer and Groves 1991, Brady pers. comm. *in* Clarkson 1992) though it may not be the case in very large streams (Smith 1996). Fishing and human presence have also been suggested as causes of disturbance; however, though specific examples exist for both disturbances, statistical data analyses are lacking (Wallen 1987, McEneaney 1994, Cassirer and Groves 1991).

Other than for boating (Clarkson 1992, Hunt 1993), wide-scale analyses have not yet been attempted nor have analyses of the effects of most specific kinds and amounts of human activities. Several specific studies should be performed to address these questions.

Initially, wide-scale data on Harlequin streams are required. Data needed on the ducks themselves include productivity and population size on each stream. Data needed on the streams used by Harlequin Ducks include length of stream segments used during pair and brood seasons, categories and locations of land ownership, hydrogeological properties, habitat

characteristics, and current human use (by roads, trails, structures, activity, etc.). A first step will be to see which of this information is already available and which is lacking that needs to be gathered in the field. Unused and/or unknown streams that fit physical parameters of used streams can then be selected and compared in respect to kind and amounts of disturbance/accessibility.

Following wide-scale analyses, Harlequin response to humans requires evaluation. Initial responses to surveyors could be recorded. Note that this would only provide immediate, in-sight response of birds seen. Presumably some birds would react prior to the surveyor seeing them and thus not be observed at all. Nor would such a study reveal length of time or distance moved in reaction to disturbance. A more precise but intrusive method would be to use radio-telemetry on the birds. Radio-telemetry would also provide more accurate data on use of habitat types and locations relative to human development/access points.

Finally, when actions are taken on Harlequin streams, monitoring to determine effects of those actions should be implemented, thereby providing for adaptive management and prevention of future mistakes. Specific land management or development actions on Harlequin streams should be proceeded by at least two years of baseline marking and surveying for population size and productivity, areas used at different seasons, habitat evaluation, and pre-action levels of human activity and development. Monitoring should continue to occur during and following the action. Actions needing special attention include road, campsite, and trail construction activity, including any increased accessibility and changes in human use of the area. Actions which might result in changes to flow regimes or water quality include mining, road building, timber harvest, industrial development, and water/hydroelectric development. Also requiring attention are changes in fishing regulations, which could alter fisherman impact on an area, and building of structures, such as industrial areas, dams, or houses, which will increase access to and use of a Harlequin stream. Possibilities for mitigation and habitat restoration can be explored during these projects.

2) What is the extent and nature of movements in breeding and wintering areas?

This information is needed to determine the possibilities for natural recolonization of new and historic Harlequin occurrences, natural supplementation of existing occurrences, particularly small populations, and the strength of natal and adult fidelity to particular sites. This information is necessary for successful modeling of Harlequin populations and their stability, using both breeding and wintering ground data.

Radio-telemetry may give quick results from the standpoint of local daily movements; however, long distance (>5 km) movements may be relatively rare, and with limited numbers of ducks radioed, may not be best for long distance movement detection. For long distance and moves between years, visibly marking birds is best.

Determining fidelity to natal areas will be a long-term project. Montana has the strongest start, with 356 birds banded on the breeding grounds since 1992. Sufficient information for preliminary modeling is now available. Sufficient information for final modeling could be available following the 1998 field season.

Much data is now available in relation to wintering ground movements, and additional data is currently being collected in Washington, Alaska, and British Columbia. Sufficient

information for use in detailed population modeling should be available within 2 years. For an accurate model, data are necessary from both the breeding and wintering grounds.
3) Are distinct metapopulations (such as a Rocky Mountain breeding population) identifiable within the Pacific range of the Harlequin Duck?

Knowledge of the degree of genetic differences among and within wintering and breeding subpopulations would allow an assessment of the appropriate management units for various Harlequin conservation strategies. Dan Esler, Alaska National Biological Service, and Maggie Brown (Department of Wildlife, Fish and Conservation Biology, University of California - Davis) are currently examining this question.

4) What are the critical habitat components limiting Harlequin Duck breeding and wintering populations?

Harlequin Ducks use a wide variety of habitats on the breeding grounds, from forests to tundra. Habitat usage should be documented over a large number of study areas to identify common habitat components for comparison to available habitat; both large and small scale components should be considered.

5) How and why do productivity and survival change over time and different areas, and what are the relative impacts of these changes on populations?

Long term studies are needed to determine population parameters for incorporation into population models (with information from movements on the breeding and wintering grounds). Needed population parameters include: productivity; age-related survival; recruitment; age(s) at first breeding and/or successful breeding; age(s) last breeding; life expectancy; and causes and timing of mortality. This information can only be provided via long-term studies involving marked birds on both the breeding and wintering areas. We are currently in an optimum position to complete studies needed on the breeding grounds, with 5 years of data on the Montana breeding population. Combined with the continued marking and study of coastal populations by Alaska, Washington, Oregon, and British Columbia, many of these parameters may be known by the end of 1998.

The most difficult question to be answered involves the causes of mortality, which is not tractable given current technology. If and when small, long range mortality transmitters are available for ducks, this topic should be pursued.

6) What are the characteristics of Harlequin Duck migration? How well defined are migratory staging areas and migration corridors?

This question may not be tractable given current technology. When small, long range mortality transmitters are available for ducks, this topic should be pursued. Some answers may come from large scale marking of individuals, and perhaps by relocating radioed birds.

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